Document Number: SET 2015-0031
412 TW-PA-14480

A Simulation Testbed for Adaptive Modulation and Coding in Airborne Telemetry (Brief)

October 2014

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Test Resource Management Center (TRMC)
Test & Evaluation/ Science & Technology (T&E/S&T)
Spectrum Efficient Technology (SET)

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
25-02-2015

2. REPORT TYPE
Technical Brief

3. DATES COVERED *(From - To)*
3/13 -- 3/16

4. TITLE AND SUBTITLE
A Simulation Testbed for Adaptive Modulation and Coding in Airborne Telemetry

5a. CONTRACT NUMBER: W900KK- 13-C-0024

5b. GRANT NUMBER: N/A

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
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5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Georgia Tech Applied Research Corporation
505 10TH ST
Atlanta GA 30332-0001

8. PERFORMING ORGANIZATION REPORT NUMBER
412TW-PA-14480

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Test Resource Management Center
Test and Evaluation/ Science and Technology
4800 Mark Center Drive, Suite 07J22
Alexandria, VA 22350

10. SPONSOR/MONITOR'S ACRONYM(S)
N/A

11. SPONSOR/MONITOR'S REPORT NUMBER(S) SET 2015-0031

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release A: distribution is unlimited.

13. SUPPLEMENTARY NOTES
CA: Air Force Flight Test Center Edwards AFB CA CC: 012100

14. ABSTRACT

Objectives

- **Simulation Testbed**
  - Develop a simulation framework with adaptive input parameters
    - Apply to many research questions involving airborne telemetry applications
- **Link-Dependent Adaptive Radio**
  - Develop and test a prototype system that adapts its modulation/coding scheme based on channel conditions
    - Create a set of rules based on various channel models
    - Choose a transmission mode to maximize throughput while maintaining link reliability
    - Demonstrate adaptivity in simulation environment

15. SUBJECT TERMS
Spectrum, Aeronautical telemetry, algorithm, bandwidth, attached sync marker (ASM), Integrated Enhanced Networked Telemetry (iNET), Shaped Offset Quadrature Phase Shift Keying (SOQPSK), Orthogonal Frequency Division Multiplexing (OFDM), Bit Error Rate, (BER)

16. SECURITY CLASSIFICATION OF: Unclassified			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON 412 TENG/EN (Tech Pubs)
a. REPORT Unclassified	**b. ABSTRACT** Unclassified	**c. THIS PAGE** Unclassified	None	17	**19b. TELEPHONE NUMBER** *(include area code)* 661-277-8615

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

Georgia Tech Research Institute

PROBLEM. SOLVED.

A Simulation Testbed for Adaptive Modulation and Coding in Airborne Telemetry

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This project is funded by the Test Resource Management Center (TRMC) Test and Evaluation/Science & Technology (T&E/S&T) Program through the U.S. Army Program Executive Office for Simulation, Training, and Instrumentation (PEO STRI) under Contract No. W900KK-13-C-024.

Manufacturing Technologies

Health and Human Systems

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Information and Communication Technologies

Energy and Environment

Outline

- Objective
- Simulation Framework
  - Architecture
  - MATLAB GUI
  - Tunable Parameters
  - Channel Models
- Link-Dependent Adaptive Radio
- Simulation Results
- Conclusion and Future Work

Objectives

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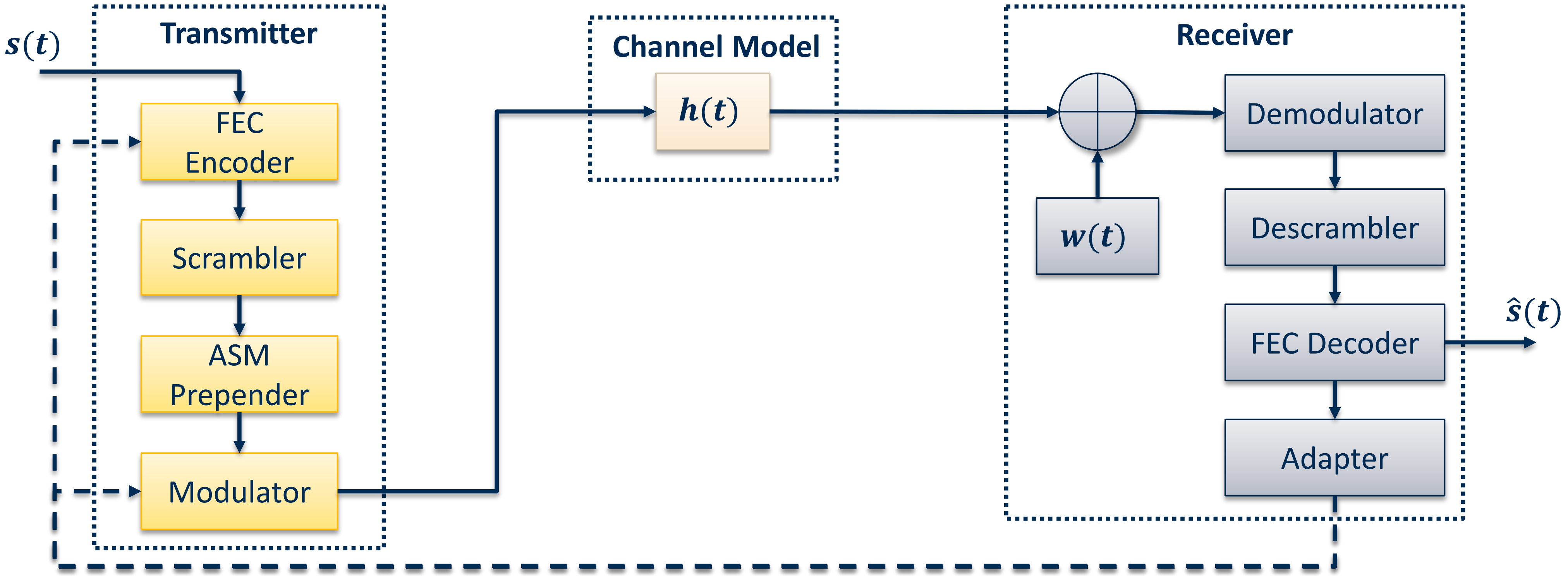
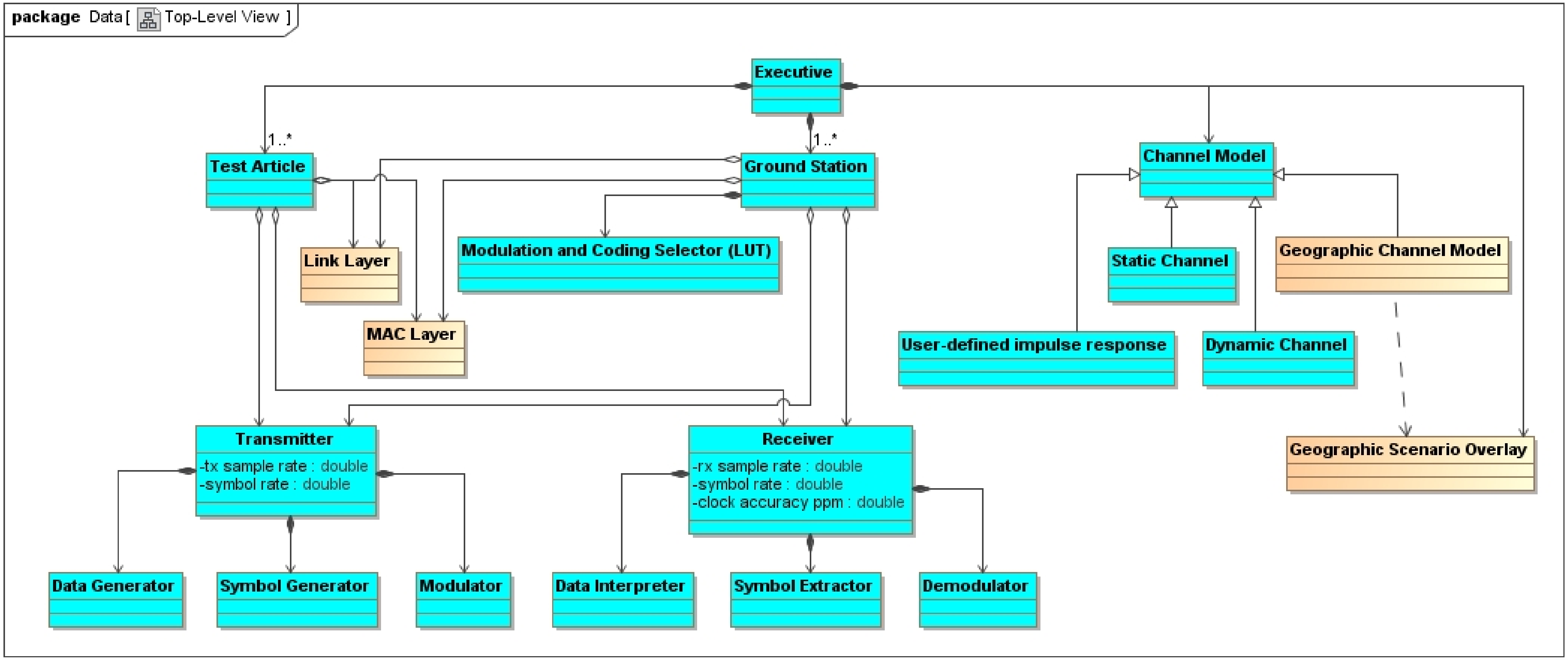
System Model



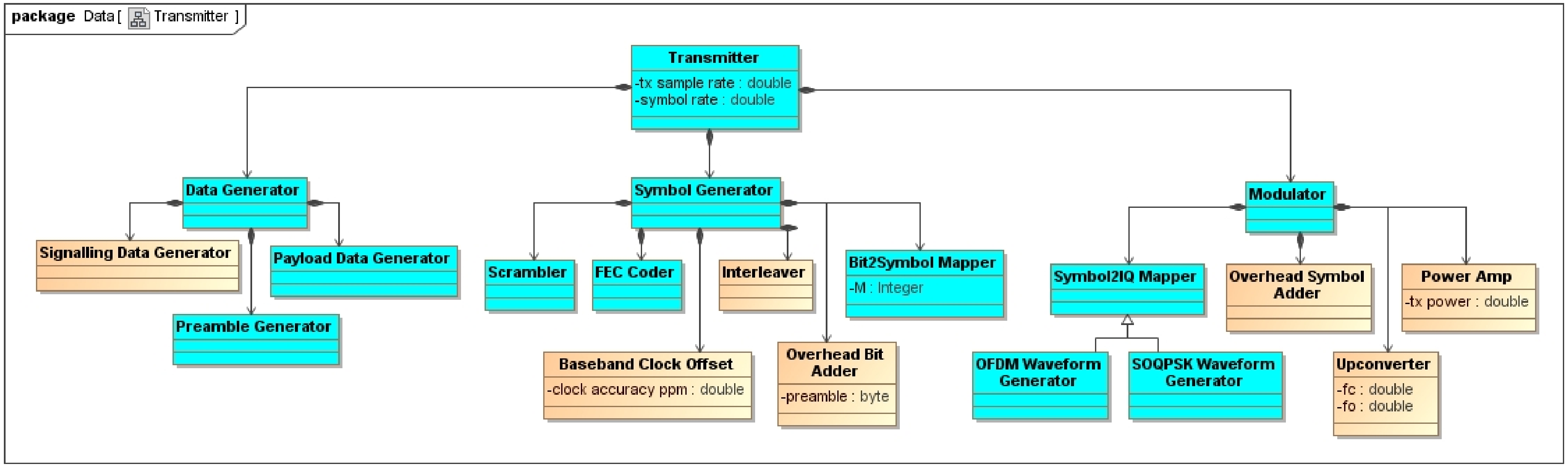
Simulation Framework Architecture

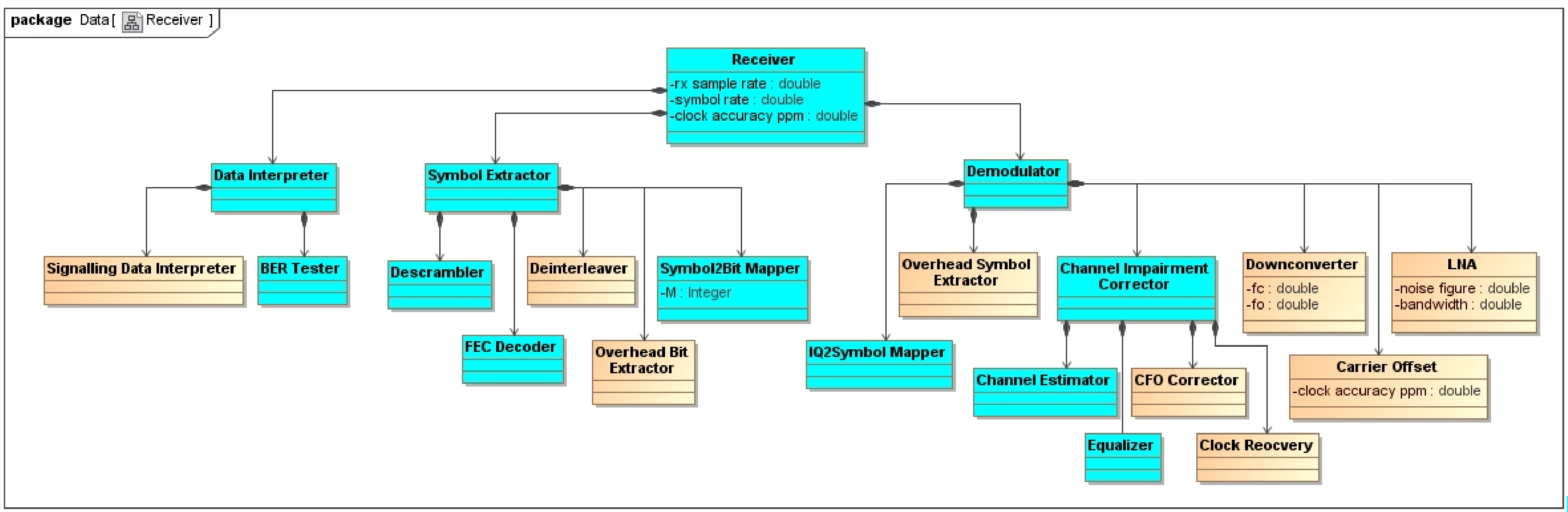
- Object-oriented MATLAB to maximize reusability and flexibility



Phase One

Phase Two





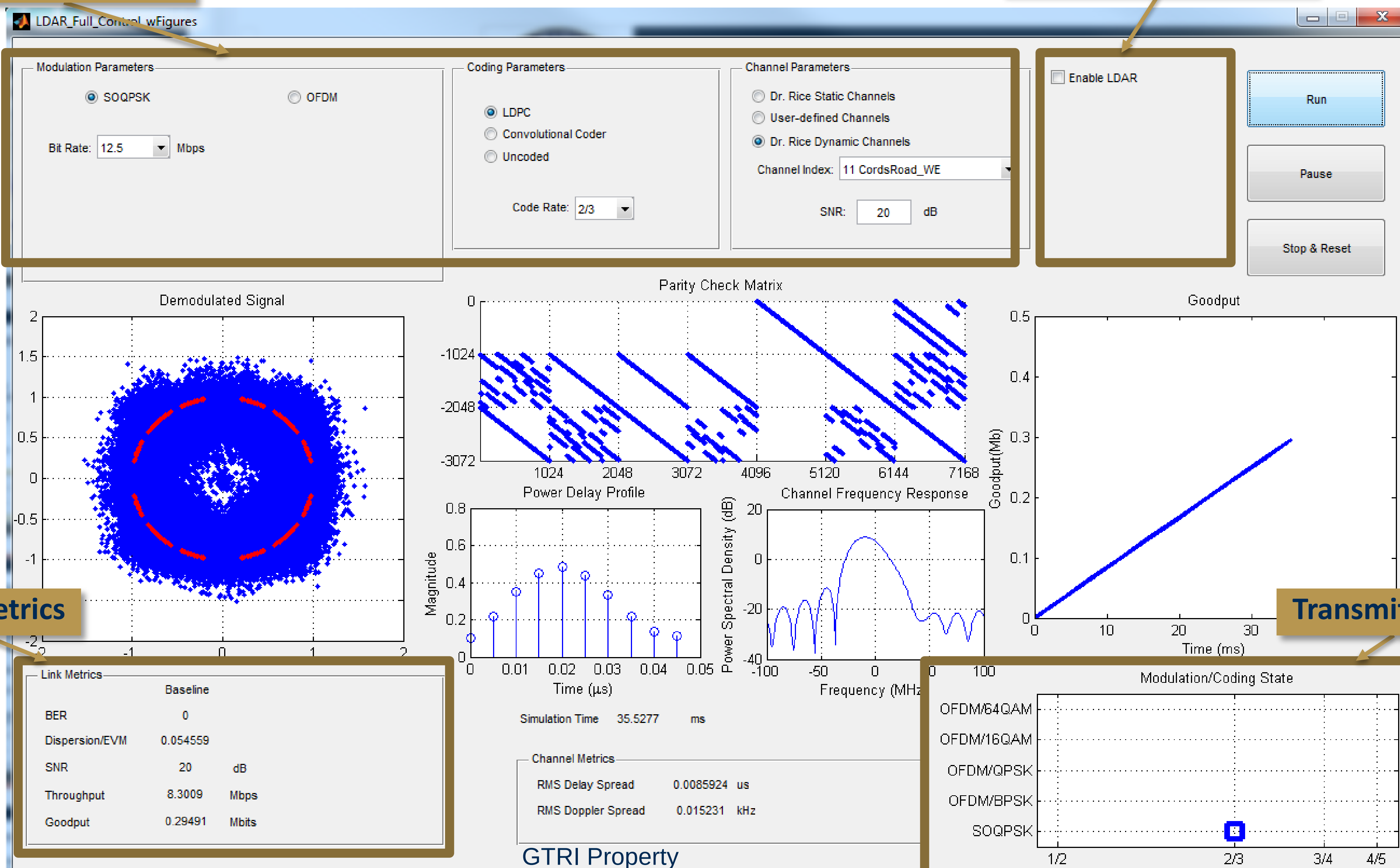
Phase One

Phase Two

MATLAB GUI Interface

Input Parameters

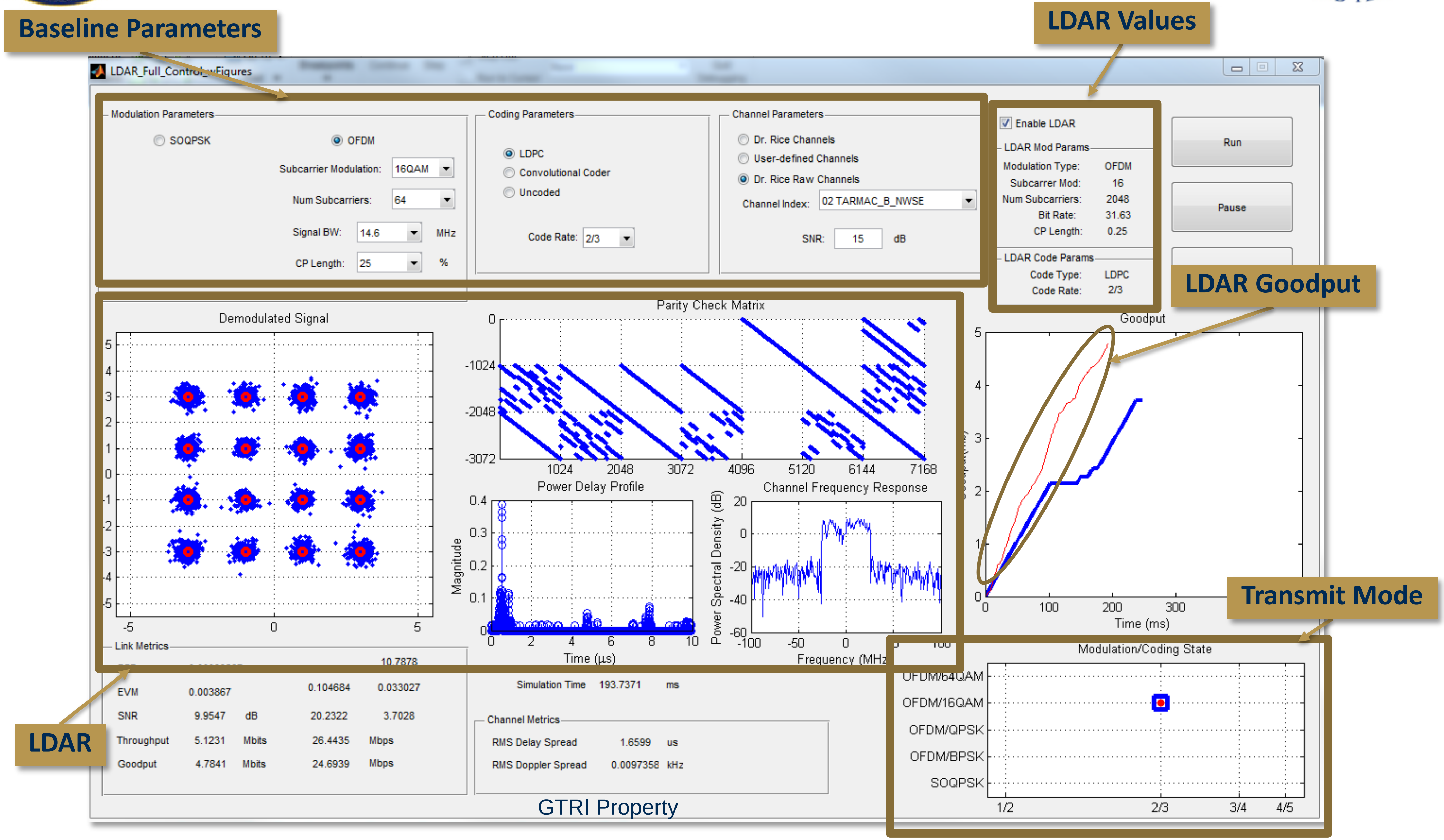
Application Selection



Link Metrics

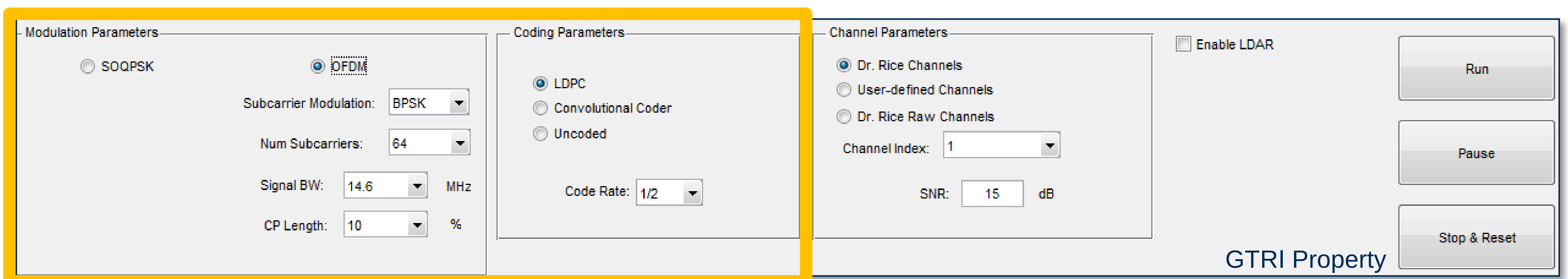
Transmit Mode

MATLAB GUI Interface



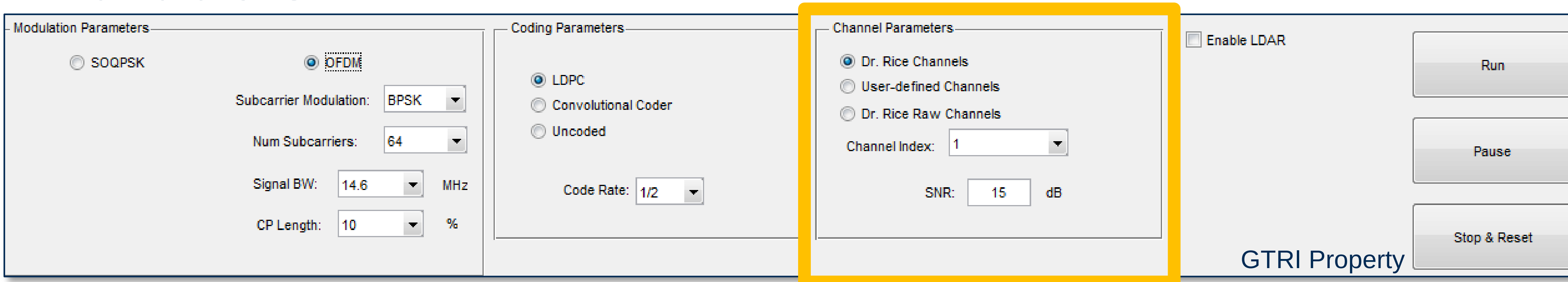
Tunable Parameters

- Modulation
  - SOQPSK
  - OFDM (IEEE 802.11a)
    - Modulations: BPSK, QPSK, 16 QAM, 64 QAM
    - Cyclic Prefix Lengths
    - Number of Subcarriers
- Coding
  - LDPC
    - Rates: 1/2, 2/3, 3/4, 4/5



Channel Models

- Static
  - Representative channels from Dr. Michael Rice’s collected data
- User-Defined
  - Arbitrary channel taps (mainly used for AWGN channel)
- Dynamic
  - Dr. Michael Rice’s collected data from airborne channel sounding runs
  - We use these to reflect the dynamics of actual telemetry channels
- Tunable SNR



Link-Dependent Adaptive Radio

- Empirically-based rule developed by GTRI
  - Collect data for each static channel
  - Create look-up tables for each static channel
    - Include values of EVM, Dispersion, BER, Throughput for various SNRs
  - Select a near-optimal transmission mode based on throughput and channel impairments
    - RMS Delay Spread
    - Error Vector Magnitude (EVM) for OFDM or Dispersion for SOQPSK

LDAR Algorithm for Selecting New Transmission Mode

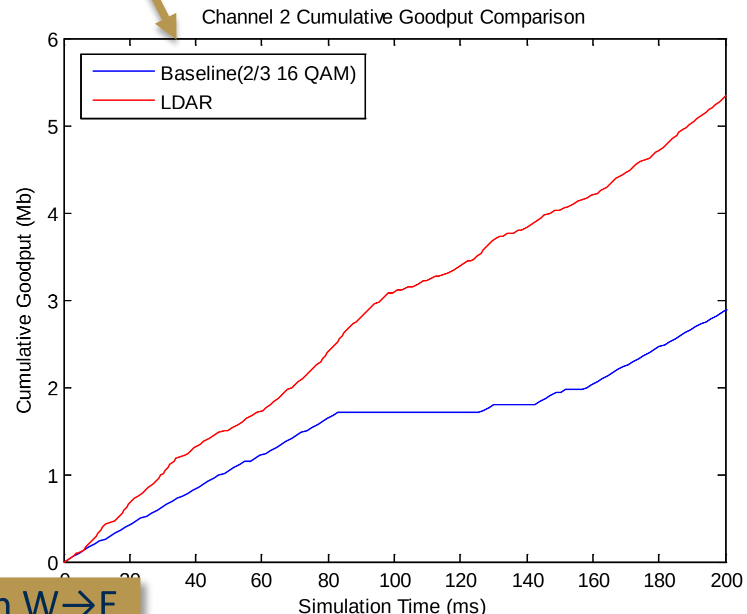
1: Compute the RMS delay spread of the current channel
2: Select a static channel that has the closest RMS delay spread as the representative channel
3: Look up the EVM/Dispersion value with the same transmission mode from the LUT of the representative channel
4: Select a mode with the highest throughput that has a BER lower than the threshold
5: Repeat Steps 1 to 4 for each delivered packet

Simulation Results

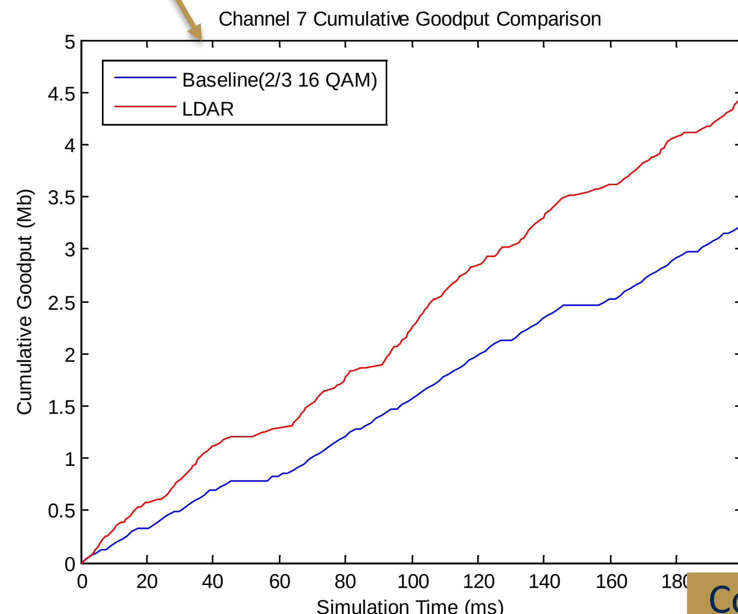
- Compare goodput performances between a baseline scheme and LDAR scheme
  - Baseline: 2/3 16-QAM OFDM
  - Burst Size: eight codewords
  - Fixed SNR: 15 dB
  - 11 Dynamic Channel Models

Dynamic Channel	Baseline Goodput (Mb)	LDAR Goodput (Mb)	Performance Increase (%)
1	4.0	5.2	30
2	2.9	5.3	83
3	0	4.2	N/A
4	2.0	4.4	120
5	4.0	8.2	105
6	0	8.1	N/A
7	3.3	4.4	33
8	0	3.7	N/A
9	3.3	5.2	58
10	4.0	8.8	120
11	4.0	8.4	110

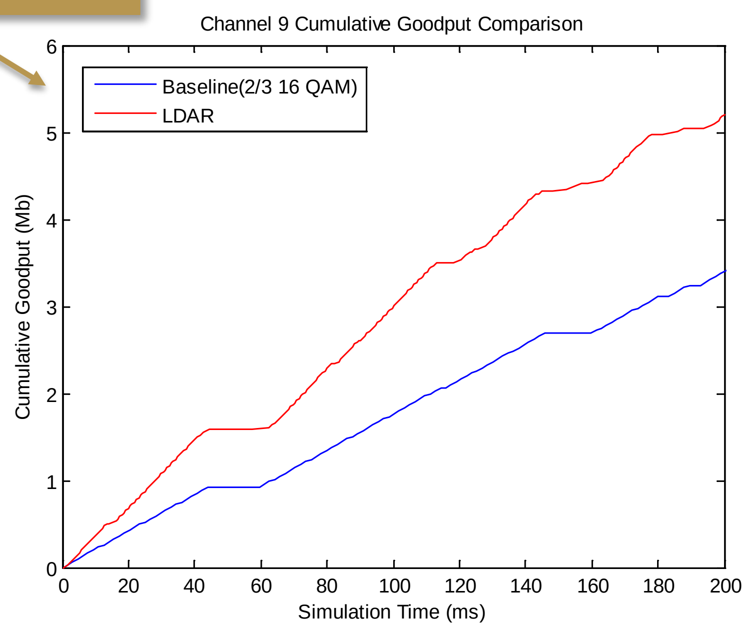
TARMAC



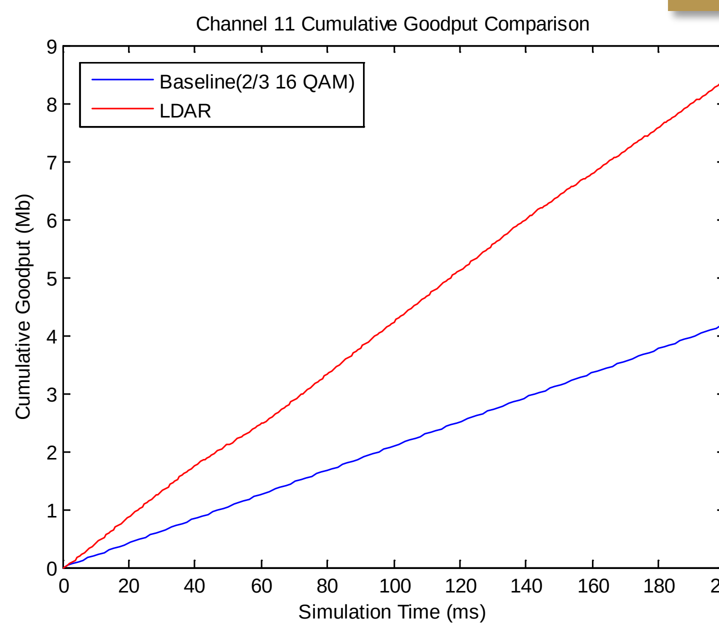
Cords Road E→W



Black Mountain W→E



Cords Road W→E



Conclusion and Future Work

- Developed a simulation testbed for aeronautical telemetry
  - Various Tunable Parameters
  - Example: Link-Dependent Adaptive Radio
  - Other Applications:
    - Tradeoffs of Phased Array Antennas
    - Utility of Multiple access schemes
    - Performance of Command and Control
- Future Work
  - Carrier Frequency Offset (CFO)
  - Doppler Shift
  - Convolutional/Turbo Encode
  - iNET Uplink
  - Mapping between EVM and Dispersion

Questions?

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